

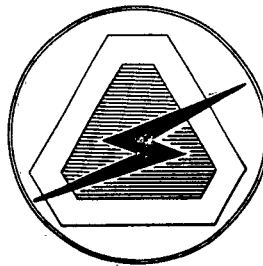
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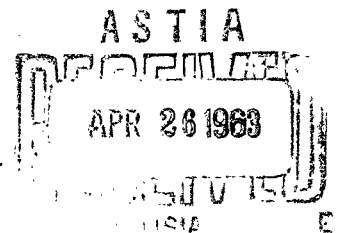
USAELRDL Technical Report 2342

THE MEASUREMENT OF HIGH INTENSITY GAMMA FLUXES
WITH VAC ION GAUGES

Basil Markow



March 1963



UNITED STATES ARMY
ELECTRONICS RESEARCH AND DEVELOPMENT LABORATORY
FORT MONMOUTH, N.J.

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THE MEASUREMENT OF HIGH INTENSITY GAMMA FLUXES WITH VAC ION GAUGES

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DA TASK 3A99-25-003-02-02

ABSTRACT

The need for a readily available gamma detector, capable of measuring the highly intense and rapidly changing fluxes of pulse sources, is filled with the use of a commercially available off-the-shelf item, the vac ion gauge, and an easily constructed cable connector.

U. S. ARMY ELECTRONICS RESEARCH AND DEVELOPMENT LABORATORY

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THE MEASUREMENT OF HIGH INTENSITY GAMMA FLUXES WITH VAC ION GAUGES

INTRODUCTION

In recent years the investigation of nuclear radiation effects on various electronic components and materials has led to the use of more and more intense sources of nuclear radiation. Many of these sources are pulsed with very rapidly changing pulse profiles. In order to be able to relate the effect with intensities, it is necessary to have an accurate flux detector, one that will follow the flux changes too.

Since the standard sources for the calibration of radiation detectors are constant and many orders of magnitude less in intensity than the sources needed for experiments, the detector response must not saturate and must be able to follow rapid changes. Such a device was designed by Dr. S. Kronenberg¹ (SEMIRAD).

THEORY

The SEMIRAD detector is basically a vacuum diode. Secondary electrons emitted from the cathode (wall) are collected on the center electrode (anode). These secondary electrons are emitted from a surface whenever a high energy electron or ion either leaves or strikes the surface. A collection voltage of several hundred volts is sufficient to collect most of the secondary electrons.

A pure gamma flux will interact with the cathode to produce Compton electrons, photoelectrons, and electron positron pairs. No ions will be emitted from the wall.

A pure neutron flux can interact with the cathode walls in a nuclear reaction providing the wall material has a sufficient cross section for the energy of the incident neutrons. If the wall material is properly chosen the device will be neutron insensitive. Aluminum, titanium, and in fact most common metals fall into this class. However, titanium was found to be the best material with which to build a gamma SEMIRAD because of its good vacuum and mechanical properties.

Clearly, the only limitation on secondary electron emission from the cathode would be space charge limitations², and since the sensitivity of this detector is very low, about 10^{-16} amp/r/hr/cm², the current is proportional to gamma intensity up to 7×10^{14} r/hr with 100 volts on the anode of an instrument with a 30 cm² cathode.

As far as response to fluctuations in radiation intensity, it is limited only by the time of flight of electrons. This is about 10^{-9} seconds for the average detectors.

PROCEDURE

The two main problems with the experimental models fabricated until now have been: a) keeping the pressure in the detector below 10^{-6} mm Hg, and b) preventing secondary ionization chambers and cable leakage from swamping the actual signal.

In order to provide experimenters with a reliable interim instrument, various vacuum devices which contained electrodes were investigated. Although many were found suitable, the vac ion pumps^{3,4} produced by Varian Associates in Palo Alto, California were found to be the easiest to adapt. Two sizes were used: the .2 liter/sec pump and the 1 liter/sec pump. Figure 1 is a cross section of the .2 l/s pump. No drawing of the 1 l/s pump was made but it is known to possess an "egg crate" type of center electrode. The shape of this electrode does not affect the signal in any way. Figures 2 and 3 are photographs of the .2 l/s and the 1 l/s pump. Both of these pumps can be purchased already evacuated to about 10^{-6} mm Hg and the copper nipple sealed permanently. By applying a high voltage to the center electrode and using the permanent magnet, the pressure in the pump can be measured. When used as a SEMIRAD, a much lower voltage is applied and the magnet is not utilized.

With the vacuum problem out of the way, the only remaining problem was the design of a cable connector that would eliminate secondary ionization chambers. Figure 4 is a cross section of the assembled connector for a .2 l/s pump, and Fig. 5 is a detailed drawing of the parts of the connector giving dimensions. Any small machine shop can easily fabricate the components. To mount the connector on the cable, the cable is stripped back and the connector assembled as in Fig. 4. The cable braid, however, is left unconnected. The connector is then inverted and locked in a bench vise. The cable is supported so it will not move. Potting mixture is poured in through the 1/2"-diameter hole around the cable insulation. After allowing the Hysol to harden overnight, the cable braid can be properly connected. The pump's ceramic insulator makes a vacuum tight seal to the "O" ring. This connector is satisfactory for microsecond changes in gamma intensity. However, for more rapid changes the cavity between the center pin and the "O" ring should be filled with silicone grease. A similar connector with larger dimensions can be made for the 1 l/s pump.

Other connectors have also been devised. For example, pressure type BNC connectors (Amphenol 31-850) and General Radio Type 874's have been potted to both detector and cable. Although these proved satisfactory, they will not be considered in this report since more care is needed to prevent secondary ionization chambers than with the special connector above.

Figure 6 is a wiring diagram for using the vac ion pump as a SEMIRAD detector. The current measuring instrument can be a Keithley d.c. amplifier for low, constant intensity sources, or a properly terminated oscilloscope for high intensity rapidly changing fields. Calibration is usually performed by exposing the detector to X-rays of a known intensity and measuring the current with a Keithley. The wall of the pump in this schematic is shown positive, which would make the center electrode the emitter. Since the response is proportional to the area of the emitter, the detector could be made more sensitive by making the wall negative. In vac ion pumps, the area of the center electrode is nearly the same as the wall so the increase in sensitivity would be small. In other SEMIRADS, the center electrode is much smaller and the wall is almost always made negative.

RESULTS

Figures 7 and 8 are response curves for a .2 l/s and a 1 l/s pump exposed to 6×10^4 r/hr X-ray. The voltage was varied to show the plateau. This plateau remains the same even for very high intensities. It is recommended that individual instruments be calibrated before being used as detectors.

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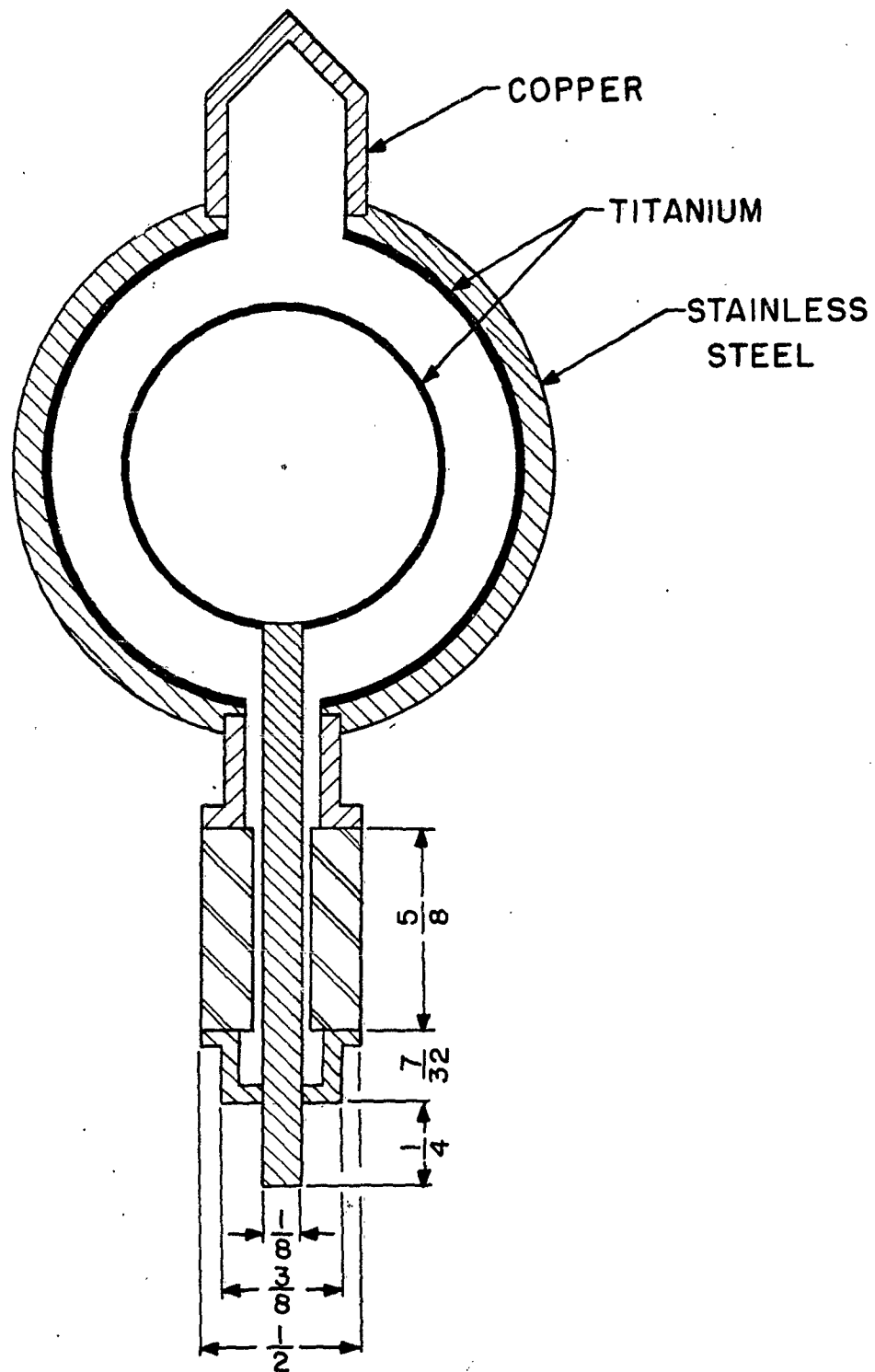


FIGURE 1. CROSS SECTION OF .2 l/s VAC ION PUMP

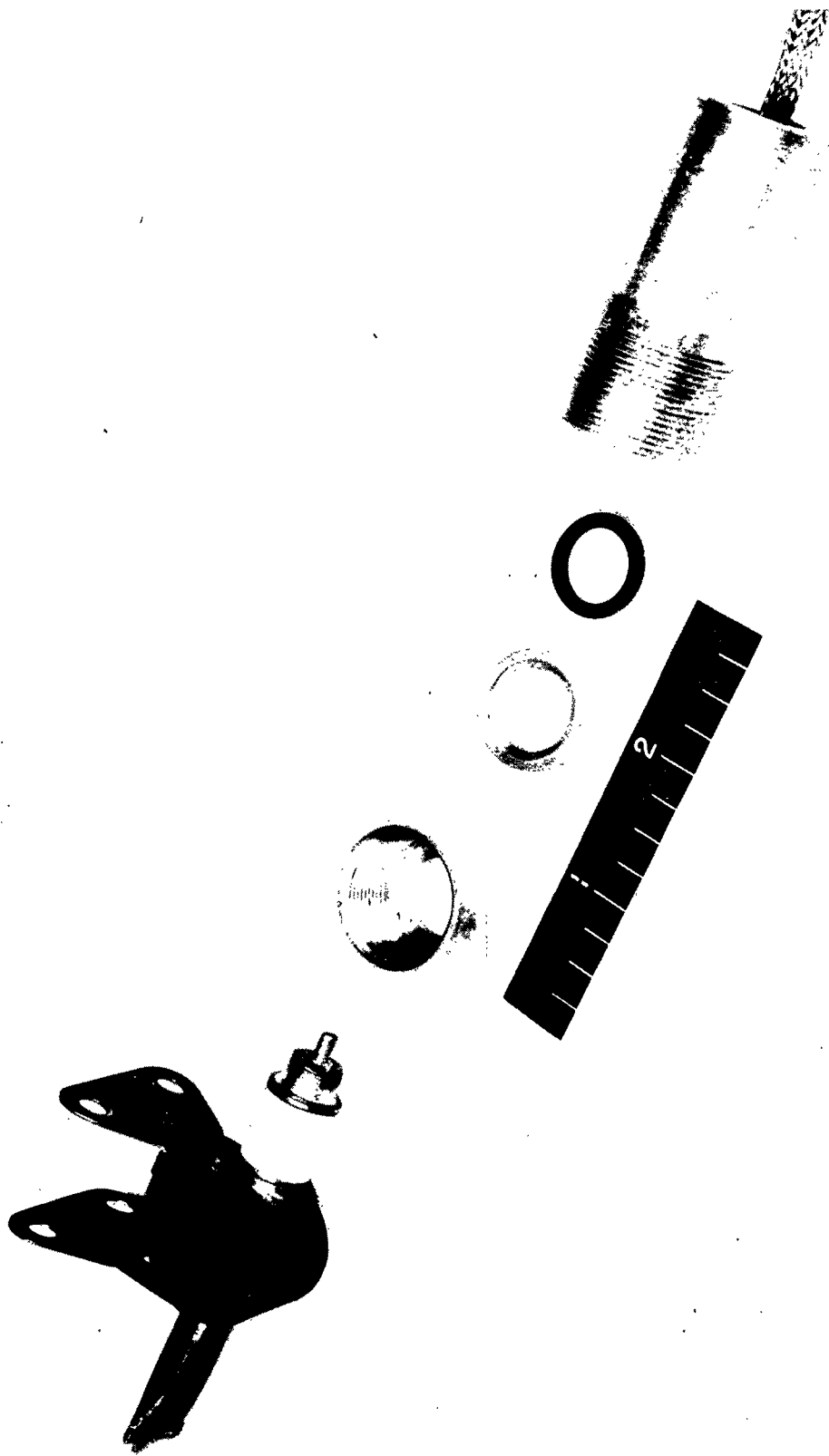


FIGURE 2. .2 &/s VAC ION PUMP SEMIRAD

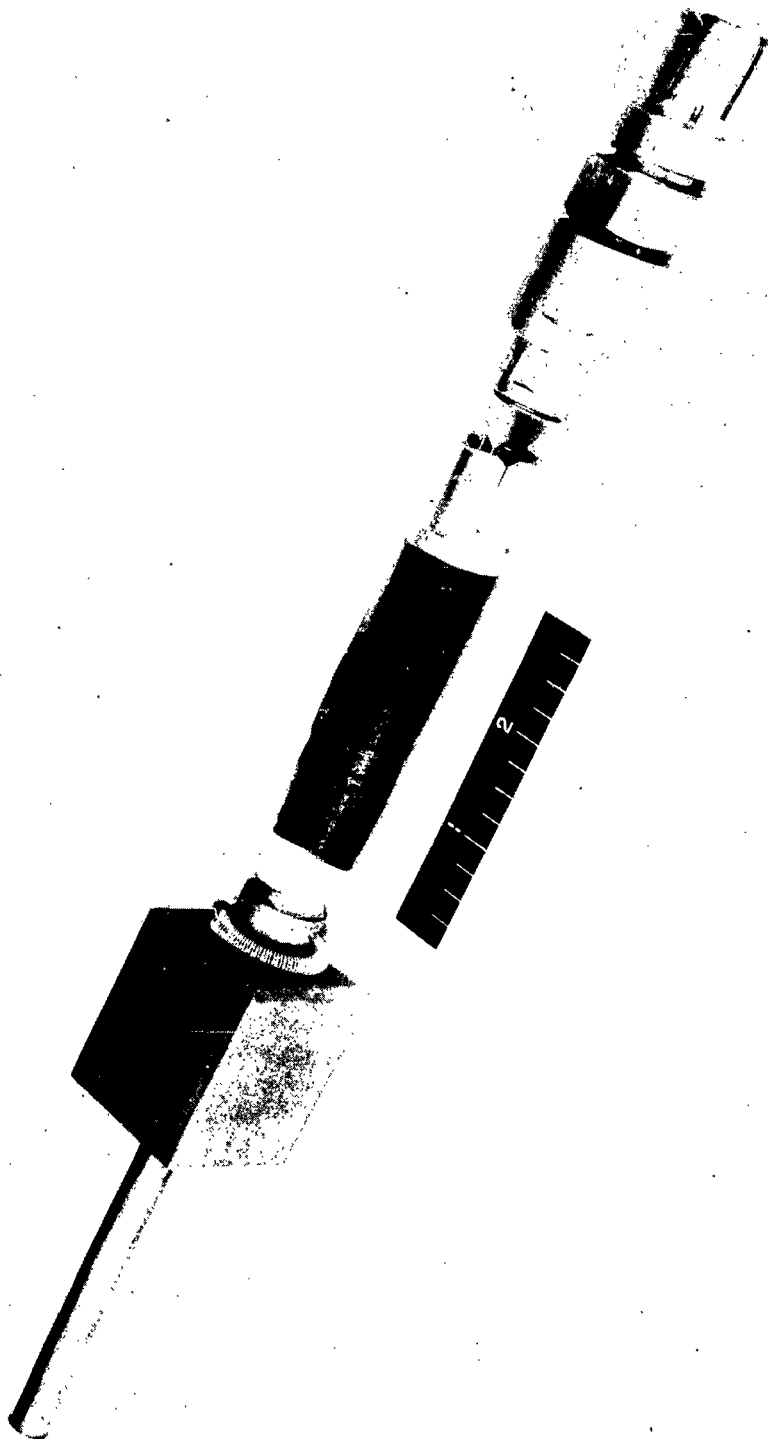


FIGURE 3. 1 & 1/2 VAC ION PUMP SEMIRAD

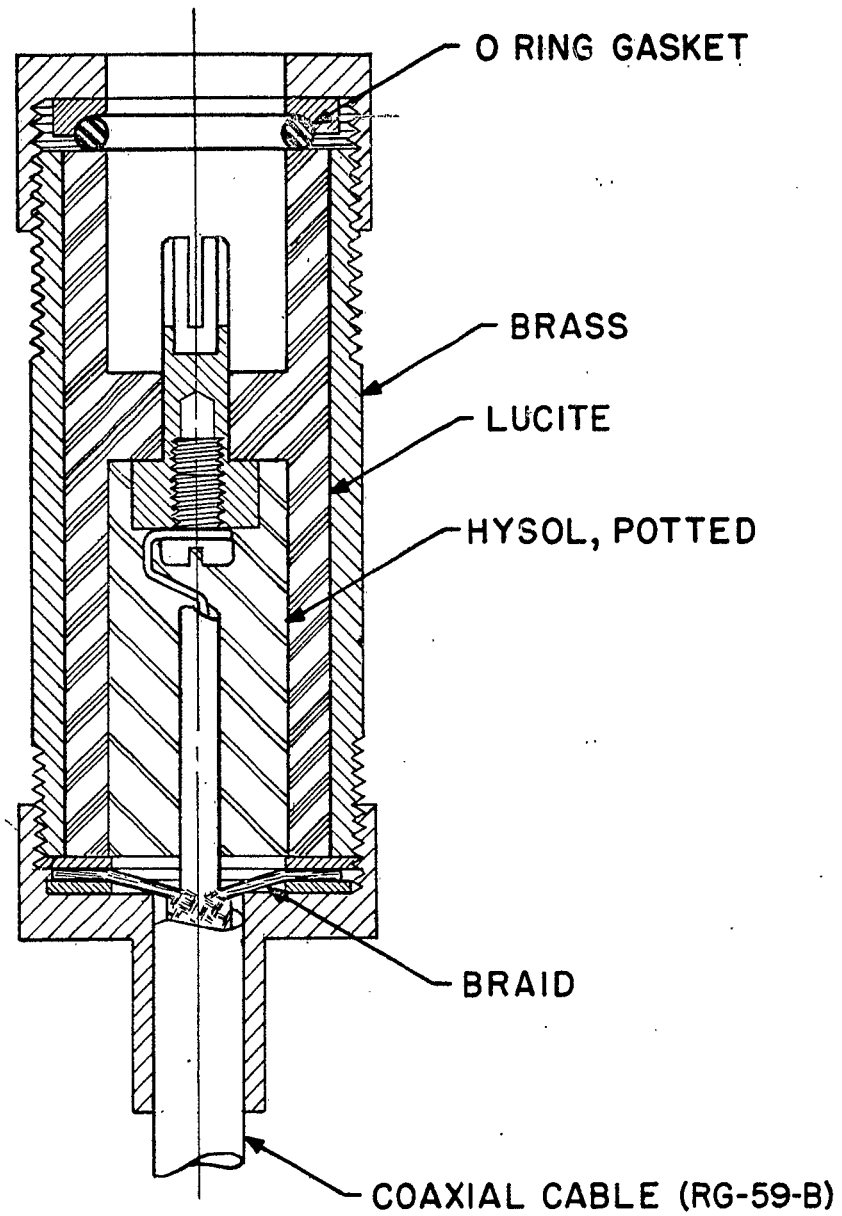


FIGURE 4. ASSEMBLY OF .2 ℓ /s VAC ION PUMP SEMIRAD CABLE CONNECTOR

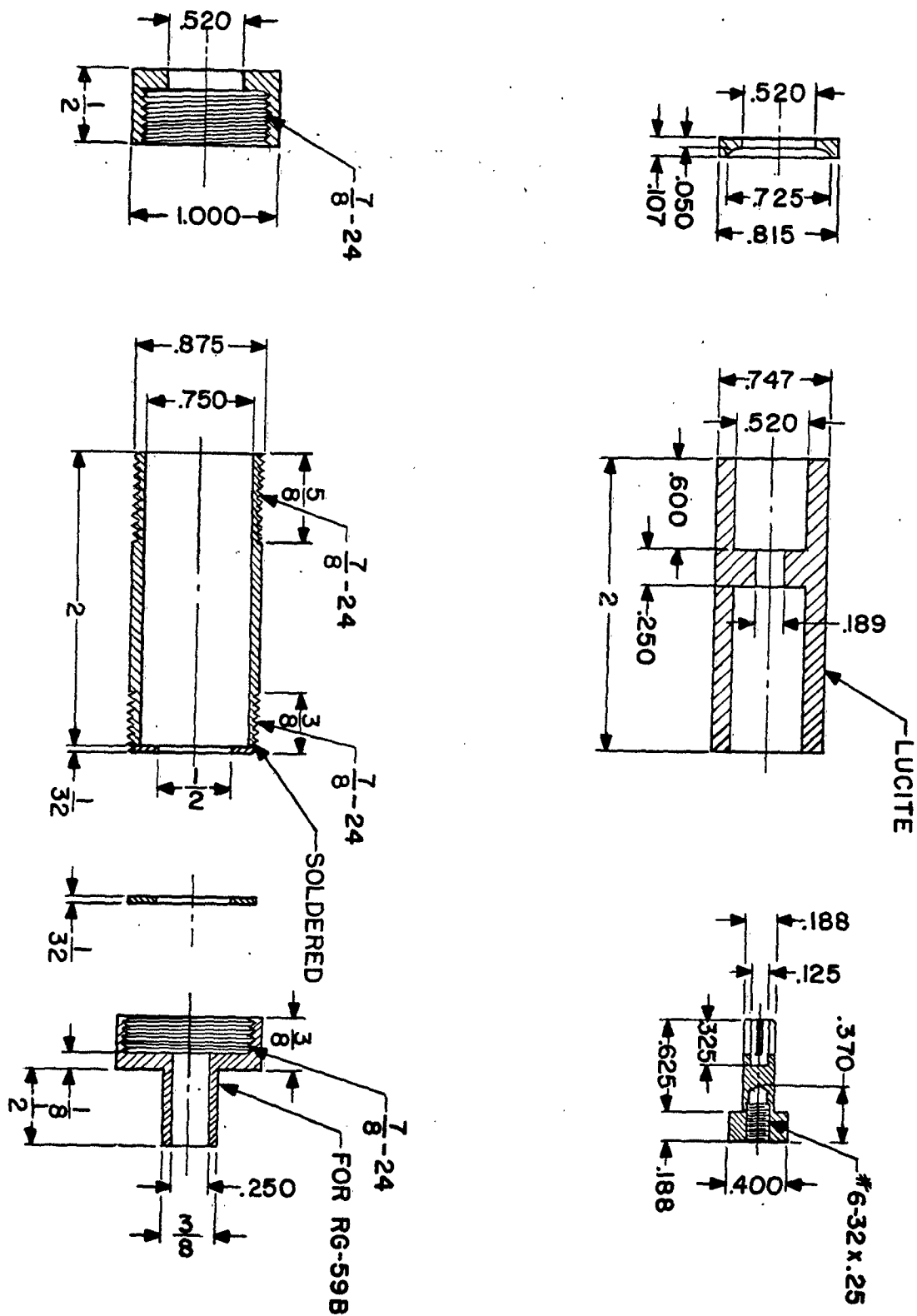


FIGURE 5. DETAILS OF .2 l/s SEMIRAD CABLE CONNECTOR

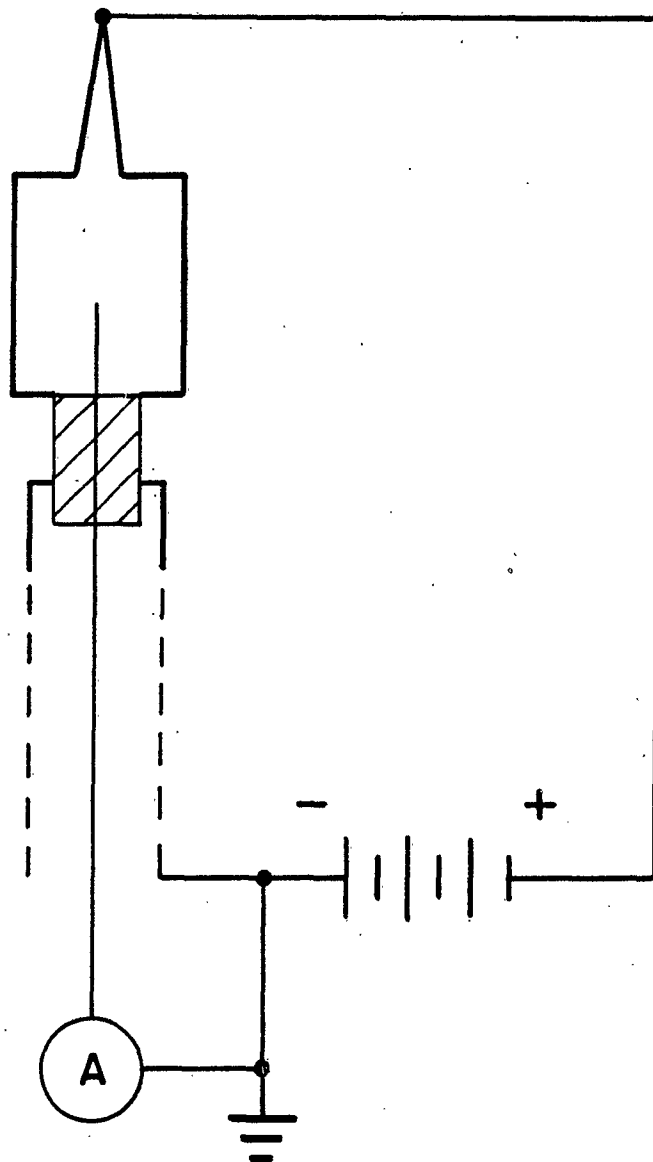


FIGURE 6. WIRING DIAGRAM FOR USING THE VAC ION PUMP AS A SEMIRAD DETECTOR

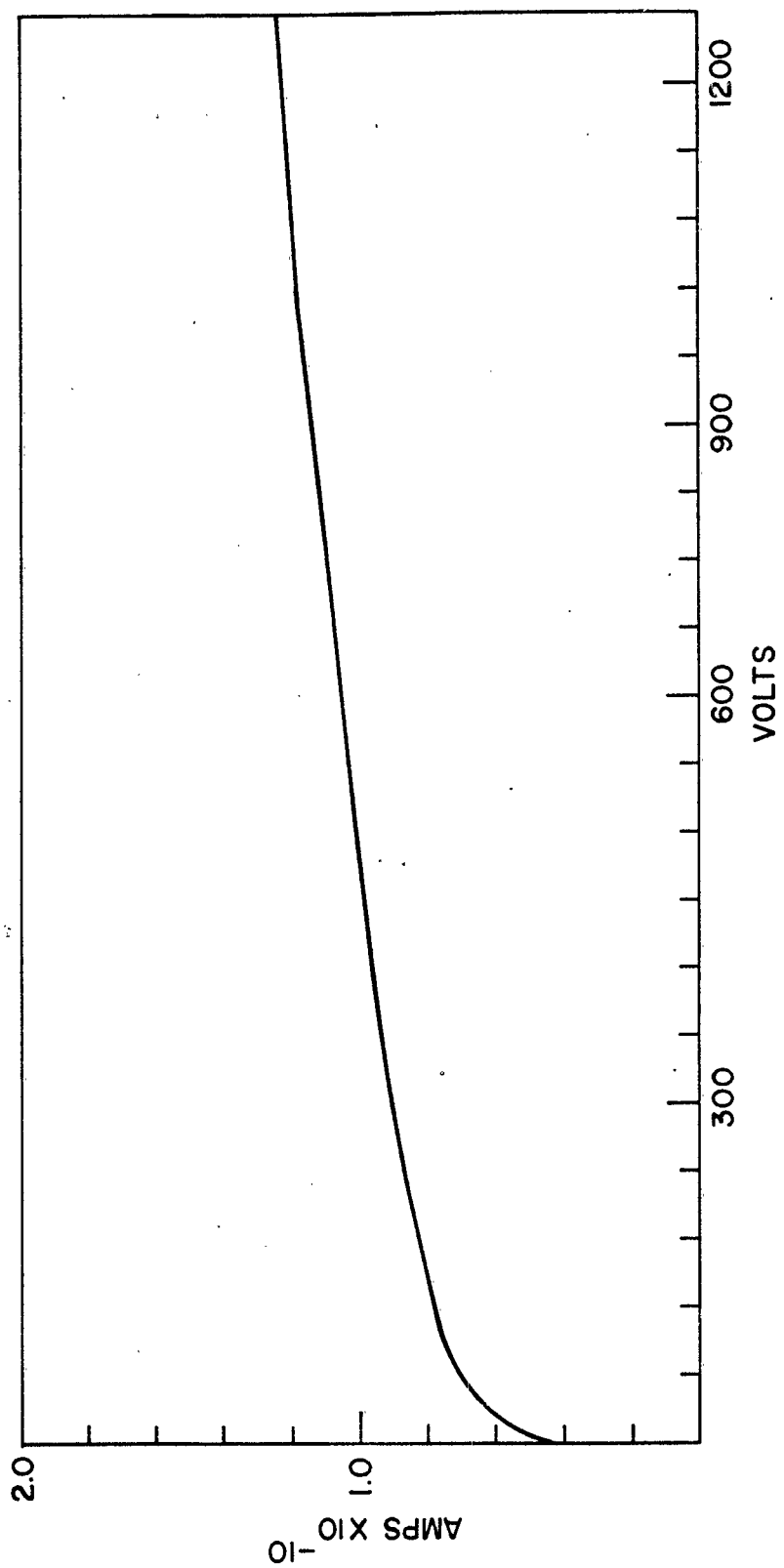


FIG.7 RESPONSE OF 1st VAC ION PUMP TO 250 KV X-RAYS (6×10^4 R/HR)

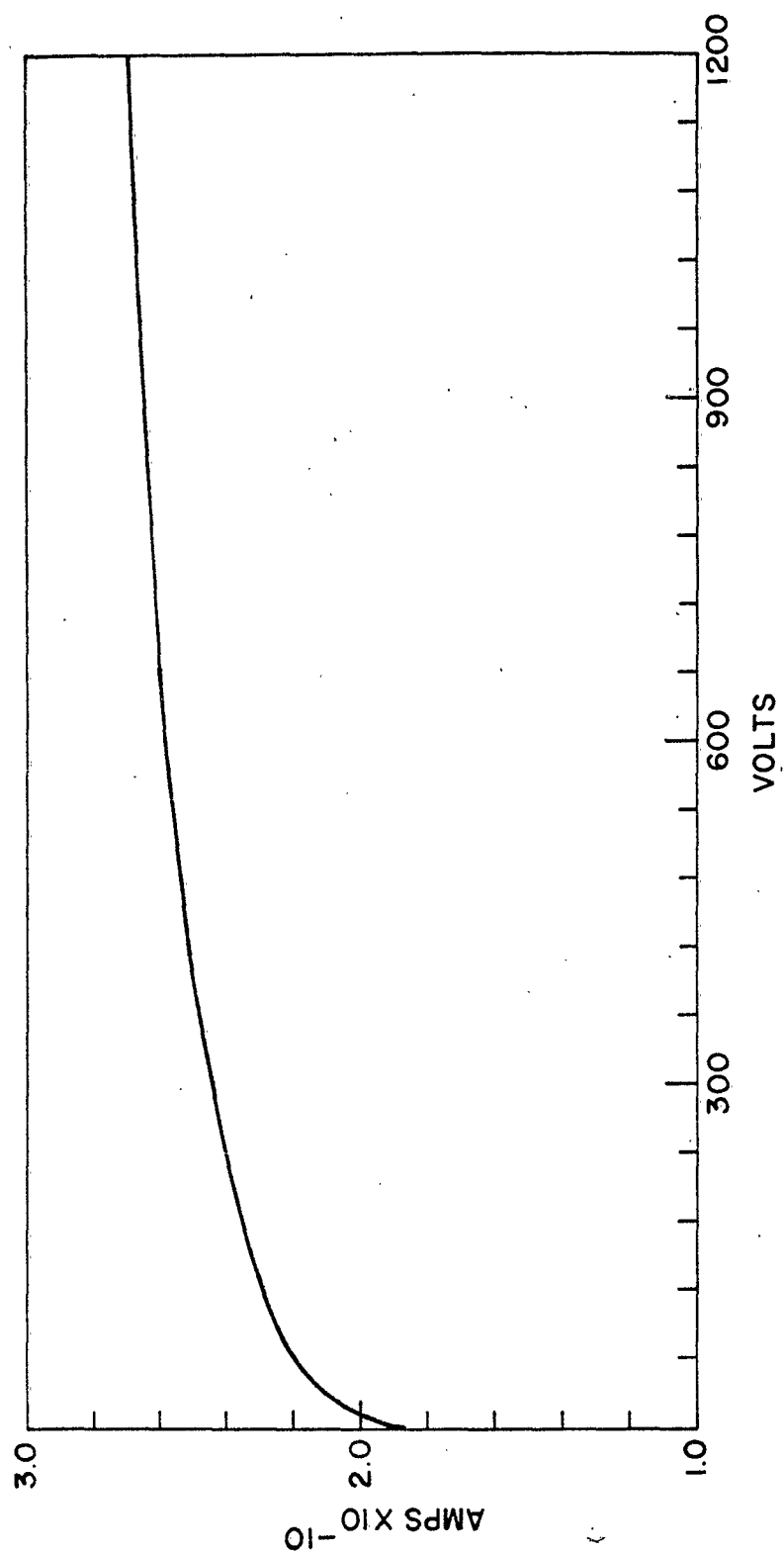


FIG.8 RESPONSE OF .2 $\frac{1}{5}$ VAC ION PUMP TO 250KV X-RAYS (6×10^4 R/HR)

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